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REPORT

OF

WIRELESS TELEGRAPHY COMMISSION.

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REPORT OF WIRELESS TELEGRAPHY COMMISSION

EXPLANATORY FOREWORD BY THE VICE-CHAIRMAN.

1. THE severely technical nature of this report requires that something in the nature of an explanatory summary should be attached to it.

2. The first section of the report gives the terms of reference of the Commission and also a recapitulation of the recommendations of the Imperial Wireless Telegraphy Committee (1919–20), which the Commission were instructed to follow. The next sixteen paragraphs then deal in a broad way with the problems regarding masts, antennae, machinery and apparatus presented by the installation of thermionic valve plant on a scale larger than hitherto attempted, and describe the solutions arrived at. Special attention is paid to the thermionic valve plant itself, to the ability of the industry to meet the probable demands, and to the question of capital and maintenance costs.

3. The visit of the Commission to the Marconi Company's station at Carnarvon is referred to. The conclusions drawn are, firstly, that the installation at that station is approaching the order of magnitude required in the Chain stations: and, secondly, that the Marconi Company is in a position to supply full size thermionic equipment for the Chain stations. The Carnarvon station has succeeded in communicating with Australia direct at certain hours of the day and therefore it is certain that the Chain station in England, which would be of three or four times the signalling strength of the Marconi station, could communicate with Australia throughout a longer diurnal period.

4. In later paragraphs (paragraph 20 *et seq.*) improved methods of reception and the general arrangements of the receiving stations are described. Under the heading "Sites" (paragraph 25) is given an outline of the work which was undertaken by the Commission at the request of representatives of the Government of the Union of South Africa with the result of showing the advisability of erecting a new African terminal station near Johannesburg in preference to adapting the ex-German station at Windhuk.

5. The second section of the report is a short portion headed "General Recommendations." Paraphrased briefly these are to the effect that—

(1.) Thermionic valve stations should be erected in England, Canada, Australia, South Africa and India. A thermionic valve station should also be erected in Egypt to duplicate the arc station now being completed by the British Post Office at Abu Zabal. At each of the other centres, namely East Africa, Singapore and Hong Kong an arc station should be erected with space for the addition of thermionic valve plant later.

(2.) Two wavelengths should be allocated to each transmitting station.

(3.) Each country should have one receiving centre (excepting Canada) and that centre should be equipped for reception from several of the chain stations simultaneously.

6. The third section of the report consists of detailed technical recommendations. Under each country (excepting Canada) specifications are given of the masts, machinery and buildings appropriate to the locality. These technical recommendations embody a number of items of which mention should be made in this foreword :—

ENGLAND.

7. It is suggested that the Marconi Company be invited to tender for the supply of thermionic valve plant and associated equipment. [Recommendation (11).]

CANADA.

8. It is recommended that a technical conference of Canadian Government representatives should be convened to discuss with the Commission special problems arising out of the geographical circumstances of Canada. [Recommendation (13).]

AUSTRALIA.

9. Alternative designs are suggested, one of which could probably be carried into effect almost entirely by industries already established within the Commonwealth. [Recommendation (14).]

SOUTH AFRICA.

10. The plans suggested assume that the station is to be on the Rand near a bulk supply of electricity. In this event the capital cost would be smaller than that of the typical chain stations, and, if desired, running machinery could be entirely dispensed with. [Recommendation (16).]

INDIA.

11. A station similar to that planned for England is suggested. [Recommendation (18).]

EGYPT.

12. A single receiving centre for both the new valve station and the arc station is proposed, and from this centre both stations would be controlled. Special receiving apparatus is proposed. [Recommendation (19).]

EAST AFRICA.

13. An arc station is proposed, drawing its electrical power from the falls of the River Thika, with reservation of the water of the Chania for future extensions. [Recommendations (21) (22).]

SINGAPORE.

14. A station equipped with arc and machinery like Leafield, Oxfordshire, is planned, but with a different antenna. [Recommendation (26).]

HONG KONG.

15. A station resembling that at Singapore, but with a less costly antenna is proposed. [Recommendation (30).]

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16. The structural work and machinery at each station have been planned with the endeavour of keeping the probable cost within the approximate estimates submitted by the Imperial Wireless Telegraphy Committee in their report. That is to say, the average cost of the overseas stations will not exceed £160,000, exclusive of the cost of erecting residences for the staffs at some of the stations. The stations in England, Egypt, East Africa, Singapore and Hong Kong, for which the Imperial Government is presumably responsible, should not exceed in the aggregate the sum of £853,000.

17. The report terminates with an appreciation of the help rendered to the Commission by the Admiralty, the War Office, the Air Ministry, the Post Office and the Department of Scientific and Industrial Research, and with a similar tribute to individuals.

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18. Looked at as a whole, the report provides specifications sufficiently full for the immediate preparation of estimates. A later report will give detailed specifications. All the stations are planned to permit of easy extension of antenna, buildings and plant.

19. Finally it should be emphasised that during portions of each day much of the Imperial strategic, official and news traffic could be carried on by direct communication between any pair of principal centres, the intermediate stations being omitted: but the intermediate stations would be necessary for relay work during the less clear portions of the day, and also for handling their own local traffic. The news messages transmitted from the principal centres could be received at many stations in the Empire, for example in New Zealand, at the cost of an inexpensive addition to their existing receiving equipment. Foreign stations in many parts of the world would be able to pick up news and propaganda from one or other of the principal centres.

W. H. ECCLES.

December 9, 1921.

REPORT.

To the Cabinet.

1. On the 23rd December, 1920, the Wireless Telegraphy Commission was summoned under the following letter of appointment:—

The Cabinet have decided to appoint a Wireless Telegraphy Commission as follows:—

The Right Hon. Viscount Milner, G.C.B., G.C.M.G. (*Chairman*).
W. H. Eccles, Esq., D.Sc., F.R.S. (*Vice-Chairman*).
L. B. Turner, Esq., M.A., M.I.E.E.
E. H. Shaughnessy, Esq., O.B.E., M.I.E.E.
Lieutenant-Colonel C. G. Crawley, R.M.A., M.I.E.E. (*Secretary*).

with the following terms of reference:—

(i.) To decide upon the wireless plant most suitable for carrying out the scheme of Imperial wireless communications recommended by the Imperial Wireless Telegraphy Committee, bearing in mind the necessity for the co-ordination of the Chain with existing telegraph services, and to design the necessary stations.

(ii.) To make recommendations regarding the actual sites for the stations proposed by the Imperial Wireless Telegraphy Committee.

(iii.) To advise generally upon the preparation of specifications for machinery and apparatus, the making of contracts and the construction of the stations.

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2. *The Recommendations of the Imperial Wireless Telegraphy Committee*, 1919-20.

(1.) That a scheme of Imperial wireless communications be established connecting the communities of the Empire by geographical steps of about 2,000 miles each, as indicated on the accompanying map.

(2.) That the wireless system employed be that involving the generation of radiotelegraphic energy by thermionic valves.

(3.) That the service of communication between Leafield and Cairo by Poulsen arcs, shortly to be in operation by the Post Office, be the first link in the chain of communication with the British communities in Africa, and that this communication be continued by a valve station near Nairobi, in East Africa, and by the alteration of the ex-German station at Windhuk to a valve station to complete the connection with the Union of South Africa.

(4.) That for communication with India, the Far East and Australia. valve stations be erected in England, near Cairo, at Poona (or other Indian station), at Singapore, at Hong Kong and in Australia at Port Darwin or Perth.

(5.) That similar communication be established by valve stations between England and Canada, subject to decision in conference between the Imperial and Canadian Governments.

(6.) That the stations be planned by a Wireless Commission of about four members, as herein described, whose functions would probably cease with the completion of the stations, and that the construction of the stations be entrusted to the Engineering Department of the General Post Office and the corresponding Dominion and Indian authorities, according to the plans furnished by the Wireless Commission.

3. The first meeting of the Commission took place on the 3rd January, 1921, and forty-six formal meetings have been held. In addition, there have been meetings in sub-committee, and visits of inspection to wireless stations at home and abroad.

4. As the thermionic stations projected by the Imperial Wireless Telegraphy Committee were of unprecedented magnitude and of a new type, nearly every item of the equipment of the wireless stations has had to be specially considered: this work will be described briefly under the headings Development of High Power Thermionic Sets, Choice of Wavelength, Transmitting Antennae, Masts and Towers, Earth Screens, Power Supply and Electrical Machinery, Emergency Receiving Gear and Operating Apparatus,

Methods of Reception and Design of Receiving Stations, Sites and Buildings. All these factors are mutually dependent.

Development of High-Power Thermionic Sets.

5. The Imperial Wireless Telegraphy Committee recommended that the thermionic transmitter should be capable of delivering at least 120 kilowatts to the antenna and indicated that double this power appeared to be within the bounds of possibility at an early date. The Commission have, therefore, made it their first duty to watch progress in these matters in all parts of the world. At home the work of the Admiralty is especially notable; at Signal School, Portsmouth, very large silica valves have been constructed and used. Every effort has been made by the Admiralty to hasten the establishment of an industry for the manufacture of these valves. At the present date the 2½ kilowatt silica valves are being produced at the rate of about four or five per week.

6. In order to equip a typical Chain station with silica valves, about 24 would be required to deliver 120 kilowatts to the aerial, not allowing for spares. The annual consumption of valves by such a set working twenty-four hours every day without cessation would be, according to our information, between 36 and 108 per station. A more precise estimate cannot be made because insufficient time has elapsed since the manufacture of these valves began. Thus, on the basis of incessant operation, eight Chain stations would consume between 288 and 864 valves per annum. It may be concluded that the silica valve industry is only gradually approaching the condition of being able to cope with the possible demands of the Chain stations over and above those of the Admiralty and other Services.

7. If, on the other hand, glass valves be used instead of silica, about four times as many would be needed for equipment and renewals; that is to say, between 135 and 405 glass valves per annum would be required per station assuming incessant operation. In round numbers between 1,080 and 3,240 glass valves would probably be required per annum by the Chain stations if all were to operate continuously. There is reason to believe that this demand could be met.

8. The most important aspect of this question is the cost of valve renewals. The glass valves cost at present, when purchased in small quantities, about £15 each. The above rates of renewal of glass valves may cost therefore between £2,025 and £6,075 per annum per station. The silica valves cost at present about £60 each, and the expenditure upon renewals would therefore be between £2,160 and £6,480 per annum per station. It is claimed, however, that burnt filaments can be renewed in either glass or silica valves at small cost, and that the above estimates of costs of renewal of silica valves can thus be materially reduced. These claims have not yet been tested practically by any large user. In all cases, it should be emphasised, estimates of the consumption of valves will be profoundly affected by the care taken in manufacture, and by the absence or presence of skilled attention during use.

9. The above estimates of the cost of renewals relate to the method of operation in which high voltage direct current generators are employed. If alternating current were used the initial capital outlay on machinery would be greatly reduced, but the cost of valve

renewals would be increased by 50 per cent. for the silica valves and by about 66 per cent. for the glass valves. The estimates are based upon an average filament life of from 6,000 to 2,000 hours, which, though not yet demonstrated, can reasonably be expected to be achieved in the course of valve development.

10. Apart from the problem of manufacture of the valves the problem of assembling them as thoroughly practical telegraphic transmitters remains. The Commission is collaborating with the Admiralty upon this problem. A set of valves which is designed to utilise 67 kilowatts is now being erected at Signal School on the Commission's responsibility.

11. Besides the Admiralty the Marconi Company have in this country been very active in the development of large thermionic sets. They have established commercial traffic across the Atlantic by means of thermionic stations of less than 30 kilowatts input at Clifden, Ireland and at Glace Bay, Canada. In Central Europe the Telefunken Company have erected plants of about the same power at two stations. In the United States of America the development appears to have been confined principally to the laboratories, and the Commission have no information regarding commercial working of large thermionic stations.

12. On the 19th and 20th November of this year, at the invitation of the Marconi Company, the Commission visited the Carnarvon station and took part in trials of the largest thermionic set yet constructed It is an assemblage of forty-eight glass valves, and is capable of working with an input of about 100 kilowatts. This is the largest set in existence and is approaching the order of magnitude laid down as desirable by the Imperial Wireless Telegraphy Committee. The set was overloaded at the trials until the input was about 150 kilowatts. The trials, which were of short duration, were very successful and included the transmission of messages across the Atlantic (of which receipt was acknowledged by wireless) and the transmission of messages to Australia and India during what are known to be the best hours of the day for reception in those parts of the globe. The receipt of the message to Australia was acknowledged next day by a cable from Melbourne. The engineers of the Marconi Company have spent much time and great ingenuity in the building up of this set, and we are confident that on the lines they have followed they would now be able to erect a set fulfilling the minimum requirements laid down by the Imperial Wireless Telegraphy Committee.

Choice of Wavelength.

13. Into the problems of choice of wavelength two factors enter, the international and the physical. An opportunity of dealing with the former factor arose in May last, when, in accordance with a decision of the Washington Conference on Electrical Communications, a meeting of the representatives of the Governments of the Allied and Associated Powers was summoned to Paris to discuss as a technical committee the allocation of wavelengths and related matters. The Imperial Communications Committee requested the Commission to hold preparatory discussions on these matters with Government Departments and with commercial Companies.

Nineteen meetings were held and a report was made to the Imperial Communications Committee from which the instructions for the British delegation to Paris were drawn up. The Provisional Technical Committee met in June, July and August, and Mr. Shaughnessy, one of the Commissioners, attended their meetings. This international aspect of the matter has been borne in mind by the Commission in the formulation of their recommendations.

14. The physical factors in the choice of wavelength have been closely studied, both theoretically and experimentally, and by means of accumulated records. Mr. Turner spent the month of September in Egypt observing the legibility of prearranged signals despatched from the Admiralty station at Horsea. For the purpose of these trials this station was equipped with a thermionic set of about 30 kilowatts input, and it emitted, according to programme, a series of signals at various wavelengths at all hours of the day and night upon selected days. Mr. Turner has written a report upon this work which has been discussed by the Commission. The main conclusion is that for distances such as those in the links of the Imperial Chain the best signals are those obtained at night by the use of relatively short waves, while the best day signals are those using long waves. The month of the trials is one of the worst months of the year for atmospheric disturbances in Egypt.

Transmitting Antennæ, Masts and Towers.

15. Perhaps the chief of the various considerations that enter into the choice of an antenna for a new type of transmitter may be expressed by saying that the choice lies between low antennæ of great area on the one hand and high antennæ of smaller area on the other. In cases where the generation of oscillatory energy is expected to be cheap and the supply abundant the former alternative may be taken, but in the case of thermionic oscillators, where plant large enough for the task is being made with difficulty, the high antenna of relatively small area is preferable. The preference is independently supported by a deeper study of the better wave-making properties of high as compared with low antennæ. From the nature of the thermionic oscillator, moreover, it can be shown that a symmetrical antenna is more suitable than an unsymmetrical one, whether a low or a high antenna is concerned.

16. The masts or towers used for supporting the antenna constitute the most costly item of a wireless station. Moreover, unless properly designed, they affect by their presence the emission of waves from the antenna and cause great loss of the oscillatory energy generated by the thermionic apparatus. The ideal mast or tower would be built of insulating material; wooden structures are an approximation to the ideal, but are unsuitable for the tropics, at any rate. Steel structures, on the other hand, are conductors, and cause considerable electrical loss as ordinarily erected. A great deal of this loss can be avoided and an approach to the ideal attained by making the mast or tower in sections with insulating portions and standing the mast on an insulating base. By varying the dimensions of the insulating portions a close approach to the ideal may be made. There are some mechanical difficulties in this mode of construction, and the consideration of these details will fall within the purview of

the constructing authorities, assisted by the Commission as necessary. They do not greatly affect the capital cost, and may be regarded as subsidiary detail. The above remarks apply alike to self-supporting towers and to masts supported by guys, the guys also being segmented by insulators in the latter case. The cost of masts is much less than that of towers.

Earth Screens.

17. The high frequency currents in an antenna are accompanied by similar currents in the earth under the antenna, unless the earth is screened by a suitable grid of copper wires. Such earth currents cause great loss of electrical energy. In the case of the thermionic transmitter, it is especially necessary to reduce this loss, and therefore the utilisation of efficient earth screens at all the Chain stations is advised.

Power Supply and Electrical Machinery.

18. The electrical machinery needed for the supply of energy to a large thermionic set presents no difficulty and need not be discussed here.

Emergency Receiving Gear and Operating Apparatus.

19. In the event of breakdown or interruption of the telegraph lines connecting the transmitting and receiving centres of a duplex station the whole traffic must be conducted by simplex operation from the transmitting station. It it therefore necessary to instal at each transmitting station an emergency set of receiving gear and operating apparatus.

Methods of Reception and Design of Receiving Stations.

20. The Commission have scrutinised all the modern literature and have individually or collectively interviewed experts of this and other countries and have visited receiving stations at home and abroad. A number of alternative types of apparatus and several types of receiving antennæ were tested in Egypt during September of this year and the months following. The signals from Horsea and Leafield and other European stations were utilised in Egypt. For these trials the War Office constructed specially a complete set of apparatus comprising improvements upon that already in operation in the Aldershot–Cologne military service, and they lent to the Commission the services of an expert officer who has spent more than two months in Egypt with this and other apparatus studying the reception of long-distance signals in that difficult climate. A complete set of apparatus of new type was also supplied by the Post Office for the purpose of these trials and one of their engineers is at the present moment in Egypt continuing the work.

21. On the 19th November the Commission visited the Transatlantic receiving station of the Marconi Company situated at Towyn and saw a demonstration of Mr. Franklin's double directional antenna. The atmospheric disturbances in this country in November are, however, not comparable with those in Egypt during the hot weather and therefore the demonstration proves nothing as regards the performance of this apparatus under the tropical conditions of

many of the Chain stations. An examination of the apparatus tends to confirm the opinion that it has no anti-atmospheric merits other than those possessed by various forms of directive apparatus.

22. The Imperial Wireless Telegraphy Committee recommended that each station of the Chain should be one-way duplex, but it would seem that better use of the plant could be made if each station were provided with as many receiving posts as there are stations with which it will communicate; and, further, that each of the Egyptian stations should be assumed to communicate with both East Africa and India. Such an arrangement is quite feasible and offers the following advantages:—

(1.) Until the routes are fully loaded it allows of improved working during periods when the flow of traffic in one direction is greater than in the other direction.

(2.) During periods when bad atmospheric conditions prevail at one station and not at the adjacent stations the one station can be sending to either of the others, and when the good reception period at the one station comes the time lost can to some extent be made up by receiving from all adjacent stations at once.

23. For economy of staffing and for traffic reasons it is highly desirable that all the receiving posts of one station shall be situated together. At each of the non-terminal stations, therefore (Egypt, East Africa, India, Singapore), the receiving posts should be grouped together at one spot, distant 20 to 40 miles from the transmitting station In Egypt, East Africa and India, where the routes diverge through much less than a right angle, the line joining the transmitting site to the receiving site should be approximately perpendicular to the average direction of the signalling routes at the station; but at Singapore, where the branch to Hong Kong is nearly perpendicular to the average India–Singapore–Australia route, the receiving site should be situated approximately on the line joining Singapore to Hong Kong. In South Africa and Hong Kong the receiving site should preferably be situated 20 to 40 miles from the transmitting site approximately on the signalling route. In England the receiving post of the new station should preferably be placed with the existing receiving post at Banbury. In general the receiving site should be chosen so as to comprise a central plot, 250 yards by 50 yards for the operating building, and two other plots, 220 yards square, each suitable for containing a mast 300 feet high, about 550 yards from the central plot and on opposite sides of it. The general direction of the three plots should lie along the average direction of the signalling route.

24. Experience recently gained in England and Egypt has shown that atmospheric interference may be markedly reduced by each of three distinct methods, which may be referred to as—

(*a*.) Atmospheric balancing.
(*b*.) Limiting.
(*c*.) Barraging.

Designs are in progress for applying all these simultaneously in Egypt. If the benefits obtainable justify the expenditure, the other stations of the Chain can be similarly equipped in due course.

Sites.

25. The Admiralty have lent to the Commission the services of two officers who are now in Egypt on their way to East Africa and probably to South Africa, taking with them apparatus for making a radio-telegraphic survey, and instructed as to the other requirements the sites must fulfil and the data to be collected. They will probably visit Singapore and Hong Kong. At the invitation of the Indian Government, an engineer from the Post Office will visit India in connection with receiving tests organised by the Indian Government, and will place his services at the disposal of that Government in respect of the choice of a site, if desired.

26. It should be remarked that a considerable amount of information regarding possible sites in East Africa, Singapore and Hong Kong has been collected by previous expeditions in connection with the old Imperial Chain proposals, and has been placed in the hands of the Commission.

27. The Imperial Wireless Telegraphy Committee recommended (1920) the use of the ex-German Windhuk station as the South African terminal station of the Chain, being under the impression that Windhuk was adequately connected by land lines with the political and commercial centres of the Union. Later information put before the Commission by representatives of the Union Government has shown that new land lines would be required, and that the maintenance of these lines would be costly. Under these circumstances, the Commission, at the request of the representatives of the Government of the Union of South Africa attending the Imperial Conference, drew up a memorandum upon the possibility of erecting an entirely new station near Johannesburg as the terminal station of the African chain. The capital outlay would be greater than that needed for the adaptation of Windhuk, but the cost of maintenance would be less, much retransmission of messages would be avoided and better conditions for the staff could be provided. A radio-telegraphic survey of the region by aid of portable receiving apparatus will decide whether Johannesburg is sufficiently free from atmospheric electrical disturbance to be a suitable site.

Buildings.

28. The advantages of a symmetrical antenna have been referred to in paragraph 15. In order to ensure symmetry the buildings for housing the transmitting plant should be placed at the centre of the transmitting site. In general, there will be a boiler house, an engine room and a high frequency room, together with workshops and an emergency operating room; but when power can be drawn from an outside supply the boiler house is not required. In view of the recommendations of the Imperial Wireless Telegraphy Committee it is important to plan the buildings in such a way that the boiler house, engine room and high frequency room can each be extended easily. The form adopted in this Report is a very economical one: it consists of two or three equal bays, as the case may be, in parallel formation, with panelled ends, each lighted from the roof, which may be of saw-tooth type. The buildings may be oriented in any direction appropriate to the locality. The dimensions shown on the appended diagrams

of the English station must be altered to suit the climatic conditions of each country.

The buildings for housing the receiving apparatus call for no special remark. They should follow generally the lines indicated on the diagrams of the English receiving buildings, but should be altered in dimensions to suit local conditions and to provide for the recommended number of route circuits.

GENERAL RECOMMENDATIONS.

The Commission recommend that—

(1.) The transmitting stations in England, Canada, Australia, the Union of South Africa, India and Egypt be equipped with thermionic valve plant in the manner described in detail below. But in view of the amount of skilled attention demanded by this plant in its present stage of development and having regard to the isolated nature of the stations in East Africa, Singapore and Hong Kong, these three stations should be equipped for combined arc-valve transmission: the arcs alone should be installed immediately and the thermionic valve plant should be added after practice has become standardised.

(2.) Each transmitting station should be capable of working with either of two wavelengths as may be appropriate to the time of day and the atmospheric conditions.

(3.) Each receiving centre should be provided with antennæ and apparatus sufficient for working simultaneously with the other stations normally communicating with it, and all the receiving and operating apparatus should be in one and the same building.

DETAILED TECHNICAL RECOMMENDATIONS.

England.

Transmitting Station.

(4.) *Masts.*—The masts should be of steel, each 250 metres high, guyed three ways with six concrete anchorages. both masts and guys insulated in sections, and designed to take a horizontal pull of 10 tons at the top and a wind load of 60 lb. per square foot with a factor of safety of 3. Four masts should be erected, one at each corner of a square not exceeding 400 metres side.

The site should allow of extension of the antenna by the addition of two masts at each end, and the whole area available should therefore be about 1 mile by ½ mile.

(5.) *Antenna.*—The antenna should be designed so as to reduce corona to a minimum, and should be especially highly insulated. Its electrical capacity should be about one-fortieth of a microfarad.

(6.) *Earth Screen.*—The earth screen should be a series of copper wires radiating from the centre of the site to its edges, and supported at not less than 8 feet from the ground by insulators.

(7.) *Antenna Tuning Coil.*—The tuning coil should be designed for an antenna current of 500 ampères, provided with tappings for tuning the antenna to wavelengths between 3,000 metres and

16,000 metres. The high frequency resistance of the part in use should not exceed one-third of an ohm at the corresponding frequency.

(8.) *Thermionic Valve Set* (provided in duplicate).—A thermionic valve set capable of delivering at least 120 kilowatts of high-frequency power to the antenna, with the necessary connections to the antenna coil, with control gear and protective devices in the anode and filament circuits, with grid leaks and condensers, relay and hand keys, air-piping for valves and keys, compressor and instruments, all connected up. The set should be capable of sub-division in stages so that a convenient fraction of the total power may be taken to the antenna at will. It should also be capable of extension until 240 kilowatts can be delivered to the antenna. Current may be supplied either from high voltage D.C. machines (10,000–12,000 volts) or by rectifying alternating current; tenders will show which is preferable from the point of view of economy.

The set should be guaranteed with respect to constancy of wave-length, purity of wave, overall efficiency at each wavelength and average cost of renewals. It must be capable of transmitting continuously at hand speed and at ninety words per minute at full power for reception at 2,500 miles.

It is suggested that the Marconi Company be invited to tender for the apparatus recommended under the headings "Earth Screen," "Antenna Tuning Coil" and "Thermionic Valve Set." If their quotation should not be acceptable, thermionic plant, &c., could be designed by the Commission after the conclusion of the work now being undertaken at Horsea, erected in England, tested, and proved designs recommended to the Dominions and to India.

(9.) *Power Supply and Electrical Machinery.*—For the generation of the electrical power supply water-tube boilers, burning oil or coal, should be used. The requirements are:—

Three water-tube boilers, each evaporating 7,000 lb., or two each evaporating 10,000 lb., of water per hour, with superheaters and economisers, pipe work, water softeners, feed-pump, together with condensers and cooling plant.

*Two 250-kilowatt turbo alternators, three-phase, 50 cycles, 3,000 volts between phases.

*Two 250-kilowatt three-phase transformers, giving 15,000 volts.

Two turbines, each driving one 50-kilowatt D.C. machine, 220 volts, and *one 30-kilowatt D.C. machine, 20 volts.

High and low tension switch gear.

The alternative mentioned in Recommendation (8) would require the substitution of the following two items for the three items marked with an asterisk:—

Two 200-kilowatt steam-driven sets giving 10,000 to 12,000 volts D.C.

Two 20-kilowatt sets giving 20 volts D.C.

Later extensions would be one boiler, one turbo alternator (or one 200-kilowatt 10,000–12,000 volts D.C. set), one transformer, one 20-kilowatt 20 volts D.C. set, one D.C. turbo generator, switch gear, &c.

(10.) *Buildings.*—The transmitting station buildings should be at the centre of the site. They comprise the sections mentioned in paragraph 28. A travelling crane is required in the boiler-house and the engine-room. Diagrams showing the dimensions are appended.

(11.) *Emergency Receiving Gear and Operating Apparatus.*—The emergency arrangements should comprise a small aerial, a receiving set of the Post Office pattern, perforators, automatic transmitters and recording apparatus.

Receiving Station for Duplex.

(12.) The receiving station should be situated at Banbury, and provided with two sets of apparatus similar to that being installed at Banbury for the Leafield-Abu Zabal link of the Chain, but supplemented by limiting apparatus. Details appear in paragraph 23. As soon as Canada enters the Chain scheme an additional aerial system and set of receiving apparatus will be needed.

Telegraph lines in duplicate connecting Banbury to the transmitting station will be required.

CANADA.

(13.) Should the Canadian Government decide to have stations at Montreal and Vancouver, the former could maintain a good service with the station in England and the latter would be able to communicate during part of the day with England and with Australia. Both stations might be as described in Recommendations (4) to (12). The Commission would be happy to confer on technical details with the Canadian authorities.

A conference should be convened at an early date.

AUSTRALIA.

(14.) The transmitting station should be as described in Recommendations (4) to (11), unless an ample public supply of electricity is available. In this latter event the transmitting station might be similar to that described in Recommendation (16).

(15.) The receiving station should have two aerial systems and three sets of receiving apparatus, with accommodation for a third outfit for direct communication with South Africa when desired. The aerial for this receiving station consists of a pair of horizontal wires each about 250 feet long supported upon two 75-feet poles. The site required is as indicated in paragraph 23 and the buildings are as indicated in the appended diagrams. When a station is built in Vancouver additional receiving equipment will be required. Apart from this, additional receiving equipment will be necessary if the Chain station is required to work across the continent of Australia.

A 12-kilowatt D.C. supply (public or oil engine) will be required for lighting, charging batteries, and running telegraphic apparatus.

Telegraph lines in duplicate connecting the transmitting station to the receiving station will be required.

The Commission have been informed that the Australian Government prefer to have the Chain station situated at Perth rather than at Port Darwin.

South Africa.

Transmitting Station.

(16.) If the transmitting station is placed near Johannesburg the masts, the antenna, the earth screen, the tuning coil, the thermionic valve set and the emergency gear should be as described in Recommendations (4) to (8) and (11). The power supply and electric machinery should be—

*Two 250-kilowatt three-phase transformers, 15,000 volts.

*Two 30-kilowatt three-phase transformers, 20 volts.

Two 10-kilowatt lighting transformers, 220 volts.

Two transformers supplying two 40-kilowatt rotary converters giving 220 volts D.C.

High and low tension switch gear.

Overhead transmission lines in duplicate.

Later extensions would be one single set of transformers and gear as scheduled.

The alternative mentioned in Recommendation (8) would require the substitution of the following two items for the two items marked with an asterisk :—

Two 200-kilowatt motor generators, 10.000 to 12,000 volts D.C.

Two 20-kilowatt three-phase transformers, 20 volts.

In each of the above schedules a mercury rectifier may be substituted for each rotary converter.

The buildings of the transmitting station should be planned with two bays in parallel formation on the lines indicated in paragraph 28.

Receiving Station.

(17.) The receiving station should have one aerial system and two sets of receiving apparatus in the first instance with accommodation for a second outfit for direct communication with Australia when desired. The nature of the buildings is indicated in the attached diagrams, and of the site in paragraph 23.

A 12-kilowatt D.C. supply (public or oil engine) will be required for lighting, charging batteries and running telegraphic apparatus.

Telegraph lines in duplicate connecting the receiving station to the transmitting station will be required.

India.

(18.) The transmitting station should be as described in Recommendations (4) to (11).

The receiving station should have four aerials and five receiving sets. Site and buildings should be as described in paragraph 23 and in the appended diagrams.

A 12-kilowatt D.C. supply (public or oil engine) will be required for lighting, charging batteries and running telegraphic apparatus.

Telegraph lines in duplicate connecting the receiving station to the transmitting station will be required.

Egypt.

(19.) The transmitting station, unless placed at Abu Zabal, should be of the type described in Recommendations (4) to (11).

The receiving station should have four aerial systems and five sets of receiving apparatus.

The site should consist of a central plot 200 yards by 50 yards, containing the operating building, &c., and two other plots 220 yards square, each containing a 300 feet mast 550 yards away in opposite directions from the central plot. The three plots should be connected by cable.

A 12-kilowatt D.C. supply (public or oil engine) will be required for lighting, charging batteries and running telegraphic apparatus.

Telegraph lines in duplicate to Abu Zabal and to the new transmitting station will be required for the purpose of remote control of both stations.

East Africa.

Transmitting Station.

(20.) The masts, antennae, earth screen, tuning coil and emergency gear should be as described in Recommendations (4) to (7) and (11).

(21.) *Arc Converter.*—Two 250-kilowatt arcs should be installed, each provided with chokes, condensers, contactors, resistances, instruments, keying inductances, keys and auxiliaries, similar to those at Leafield.

(22.) *Power Supply and Electrical Machinery.*—The hydroelectric project at Thika, reported upon by the Public Works Department, Nairobi, on 30th March, 1914, should be carried into effect, at least in part, if, as seems probable, the wireless transmitting site can be near the falls. For the purposes of the wireless station the water of the Thika is sufficient, and the proposed simultaneous utilisation of the Chania might therefore be reserved for any eventual enlargement of the wireless station.

The electrical machinery should consist of:—

Two 250-kilowatt water turbine-dynamo D.C. sets, delivering 350 ampères, with voltage regulation between 500 and 1,000 volts.

Two 60-kilowatt water turbine-dynamo D.C. sets, 220 volts.

Switch gear.

Two overhead transmission lines from the hydroelectric house to the wireless transmitting station.

(23.) Should the hydroelectric project be for any reason impracticable, the electrical supply should be generated by steam, as described in Recommendation (27).

(24.) *Buildings.*—A hydroelectric building should be provided at Thika River. The transmitting station buildings should be as indicated in the diagrams appended.

Residences for a staff of approximately six whites and twenty others should be provided.

The receiving buildings should be as shown in the appended diagrams, and, in addition, residences for the operating staff should be provided.

Receiving Station.

(25.) The receiving station should have three aerial systems and four receiving sets, with accommodation for the addition of a fourth outfit for direct communication with England should this prove desirable.

The site should be so chosen as to permit of the erection of a pole line 250 yards long across the central plot, but otherwise conforming to the description in paragraph 23.

A 12-kilowatt D.C. supply (public or oil-engine) will be required for lighting, charging batteries and running telegraphic apparatus.

Telegraph lines in duplicate connecting the receiving station to the transmitting station will be required.

Singapore.

Transmitting Station.

(26.) The masts, antenna, earth screen, tuning coil and emergency gear should be as described in Recommendations (4) to (7) and (11).

The arc equipment should be as described in Recommendation (21).

(27.) *Power Supply and Electrical Machinery—*

Three boilers, each evaporating 7,000 lb., or two each evaporating 10,000 lb. of water per hour, with superheaters, economisers, water softeners, feed pump, together with condensers and cooling plant.

Two 250-kilowatt reciprocating-engine and dynamo sets, 350 ampères D.C., with voltage regulation between 500 and 1,000 volts.

Two 60-kilowatt reciprocating-engine and dynamo sets, 220 volts D.C.

Switch gear.

(28.) The buildings at the transmitting station should be as indicated in the appended diagrams.

Residences should be erected if necessary, for a staff of six whites and thirty-two others.

At the receiving station the buildings should be as indicated in the diagrams, and residences may also be necessary for the operating staff.

Receiving Station.

(29.) The receiving station should have three aerial systems and four sets of receiving apparatus.

The site should be 250 yards by 50 yards with facilities for a pole line 250 yards long running across it, and conform to paragraph 23.

A 12-kilowatt D.C. supply (public or oil engine) will be required for lighting, charging batteries and running telegraphic apparatus.

Telegraph lines in duplicate connecting the receiving station to the transmitting station will be required.

Hong Kong.

Transmitting Station.

(30.) The masts should be of steel, 200 metres high, guyed three ways with six concrete anchorages, both masts and guys insulated in sections, and designed to take a horizontal pull of 10 tons at the top and a wind load of 60 lb. per square foot, with a factor of safety of three. Four masts should be erected, one at each corner of a square not exceeding 400 metres side.

The site should allow of extension of the antenna by the addition of two masts at each end, and therefore the whole area available should be about 1 mile by half a mile.

The antenna, earth screen, tuning coil, and emergency gear should be as described in Recommendations (5) to (7) and (11).

The arc equipment should be as described in Recommendation (21).

The power supply and electrical machinery should be as described in Recommendation (27).

The buildings should be as described in Recommendation (28).

Receiving Station.

(31.) The receiving station should be generally the same as that described in Recommendation (17).

The Commission desire to place on record their cordial thanks for the helpful co-operation unsparingly given by the Admiralty, the War Office, the Air Ministry, the Post Office and the Radio Research Board of the Department of Scientific and Industrial Research during the past twelve months. All these Departments have placed at the disposal of the Commission their technical records, their accumulated experience, and material facilities for undertaking practical trials of methods and apparatus. The Admiralty, the War Office and the Post Office have lent officers for work at home and abroad besides constructing special trial sets of apparatus at the request of the Commission. Without this assistance the work of the Commission would have been greatly protracted.

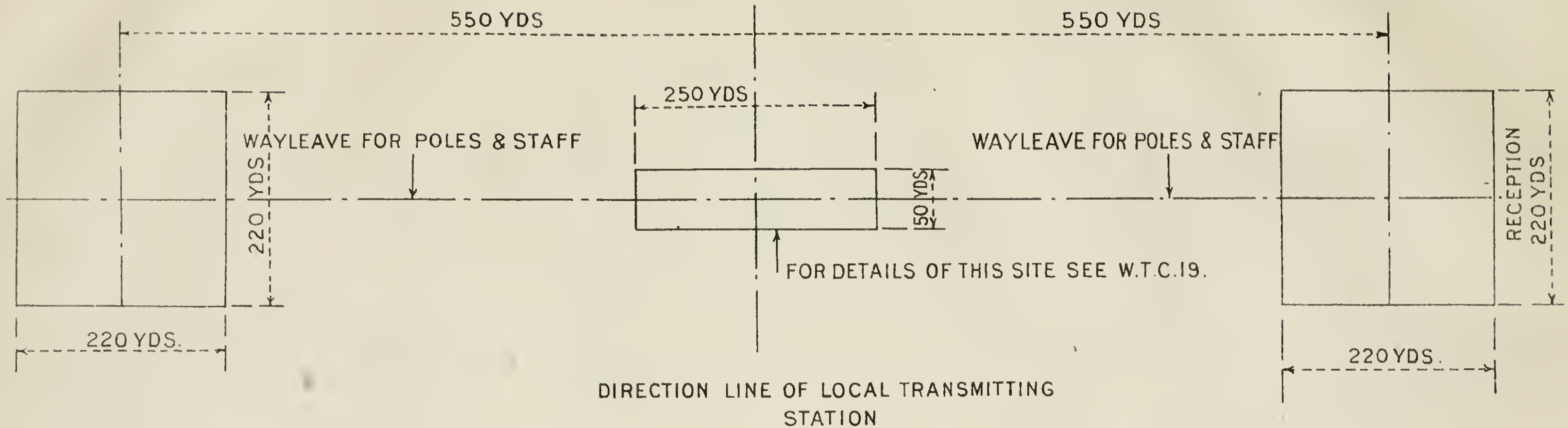
The Commission also desire to express their great appreciation of the valuable aid afforded by Colonel Sir S. H. Wilson, K.B.E., C.B., C.M.G., Principal Assistant Secretary to the Committee of Imperial Defence, by keeping them in touch with all the Departments of State consulted by the Commission upon matters relating to the Imperial wireless chain.

The Commission is especially grateful to Lieutenant-Colonel C. G. Crawley, R.M.A., Secretary to the Commission, who has carried out his work with very great efficiency.

W. H. ECCLES.
E. H. SHAUGHNESSY.
L. B. TURNER.

C. G. CRAWLEY, *Secretary.*

2, *Whitehall Gardens, S.W.* 1,
December 5, 1921.



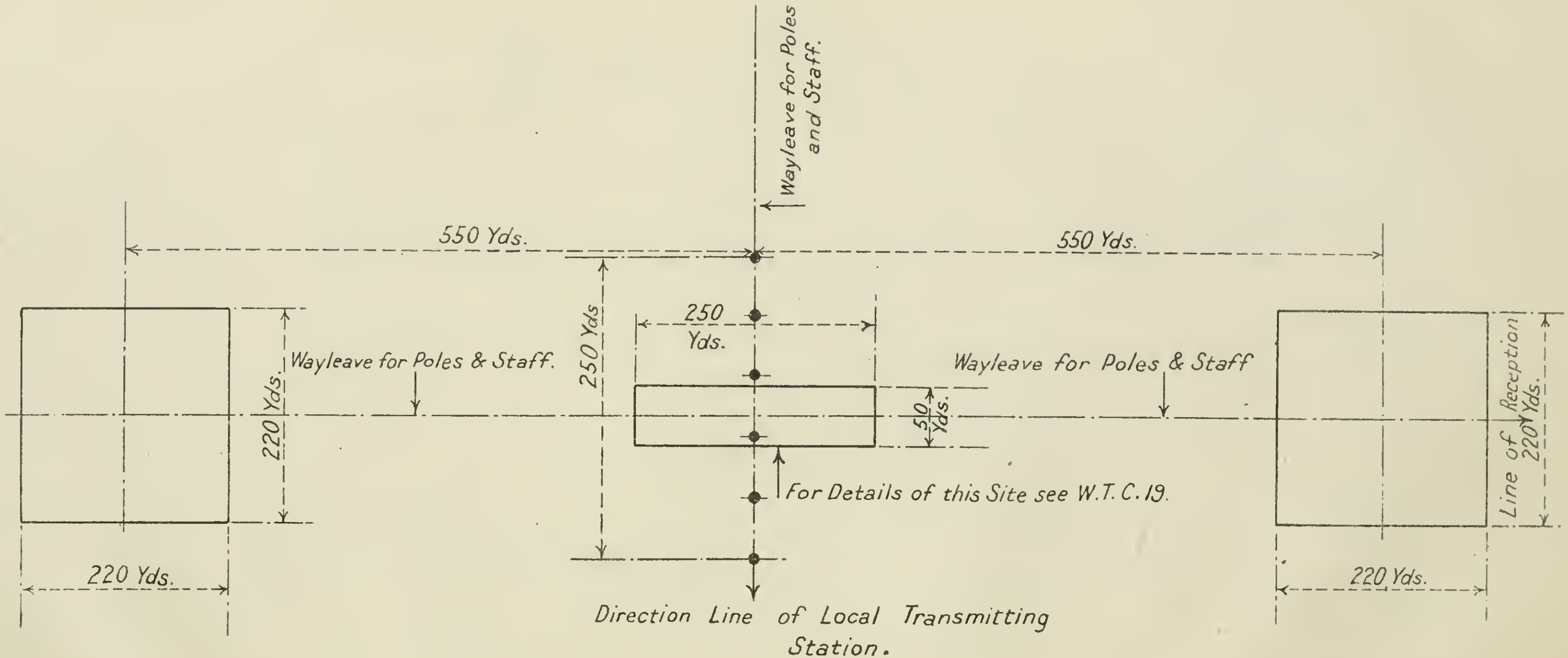
FOR IMPERIAL STATIONS

ROUGH DIMENSIONS OF RECEIVING SITE. Dec. 1921.

Wireless Station
E-in-C's Office
G.P.O. London E.C.

W.T.C. 17.

Malby & Sons. Lith.



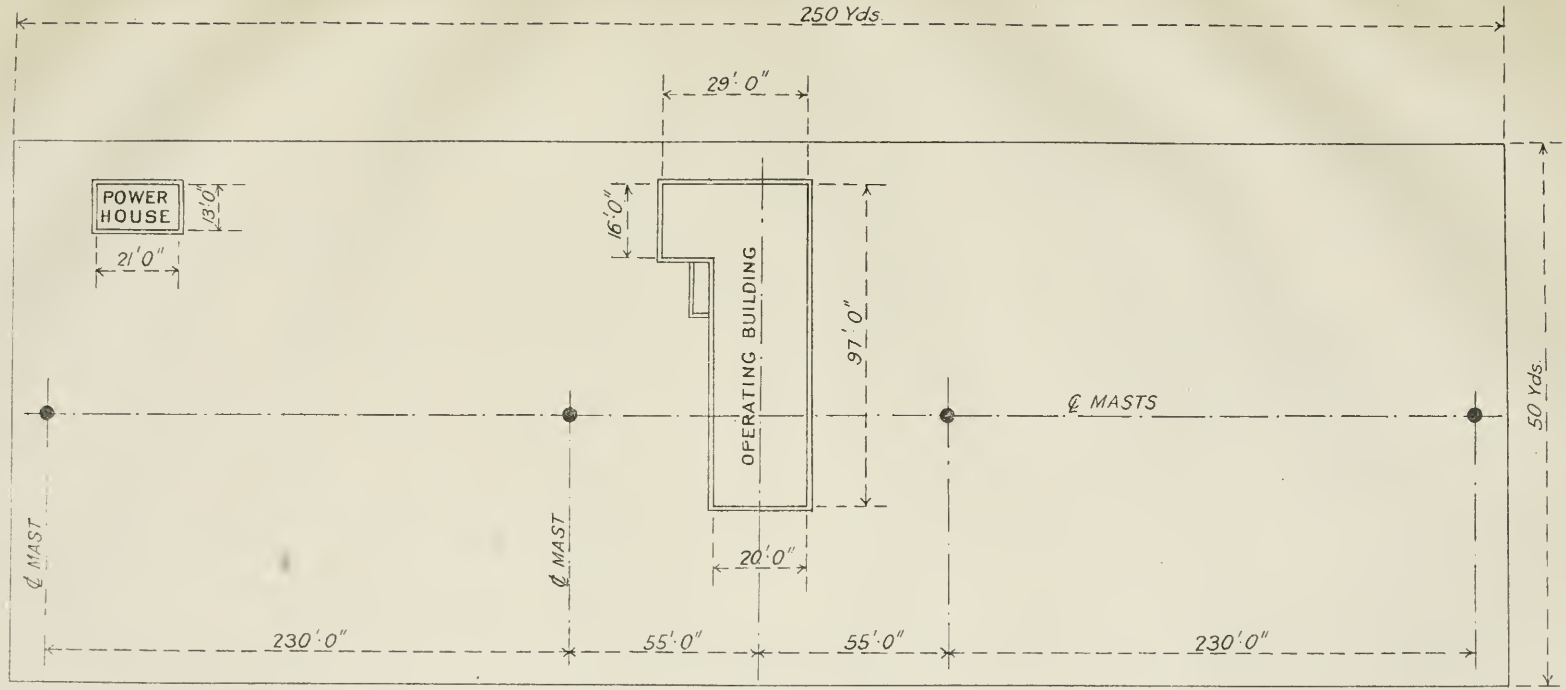
EAST AFRICA & SINGAPORE ONLY.

FOR IMPERIAL STATIONS	
ROUGH DIMENSIONS OF RECEIVING SITE (ALTERNATIVE)	
Wireless Section E-in-Cs. Office. G.P.O. London, E.C.	W.T.C. 18.

Dec. 1921.

Malby & Sons. Lith

435.



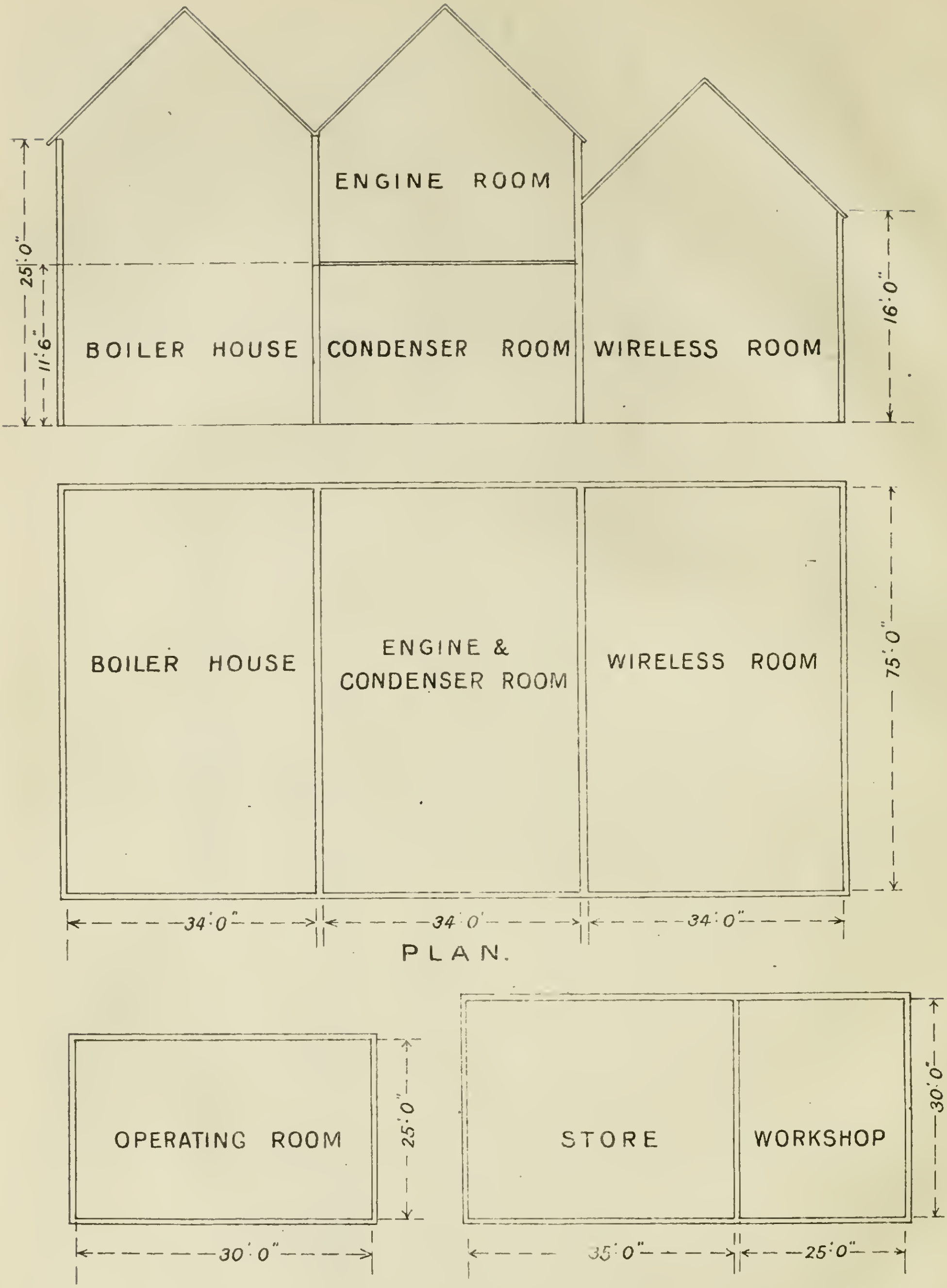
MASTS: 4.- CREO: STOUT. 75'0"

FOR IMPERIAL STATIONS PROPOSED CENTRAL RECEIVING SITE	
Wireless Section E-in-C's Office G.P.O. London E.C.	W.T.C. 19.

Dec. 1921.

Malby & Sons. Lith

435



Boiler House will be 38 feet wide if Coal is used.
Buildings to be modified according to local & climatic conditions.

FOR IMPERIAL STATIONS
ROUGH DIMENSIONS OF TRANSMITTING BUILDINGS.

Wireless Section E-in-C's Office G.P.O., London, E.C.	WTC. 20

Dec. 1921.

435 25724.2.2500 1.22.

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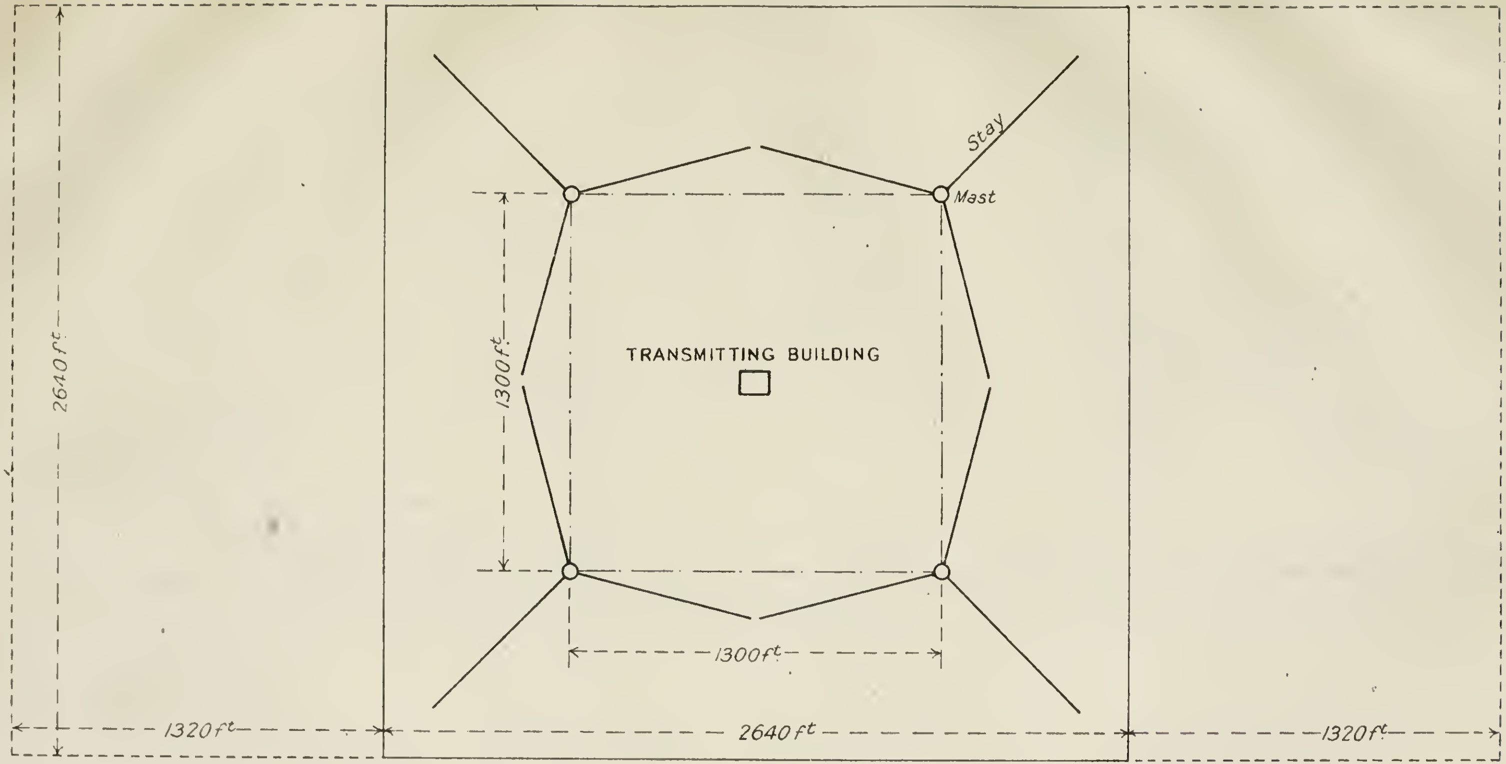

TRANSMITTING SITE PLAN.

Wireless Section
Engineer-in-Chiefs Office
G.P.O. London 13/12/21

W.T.C. 21.

435

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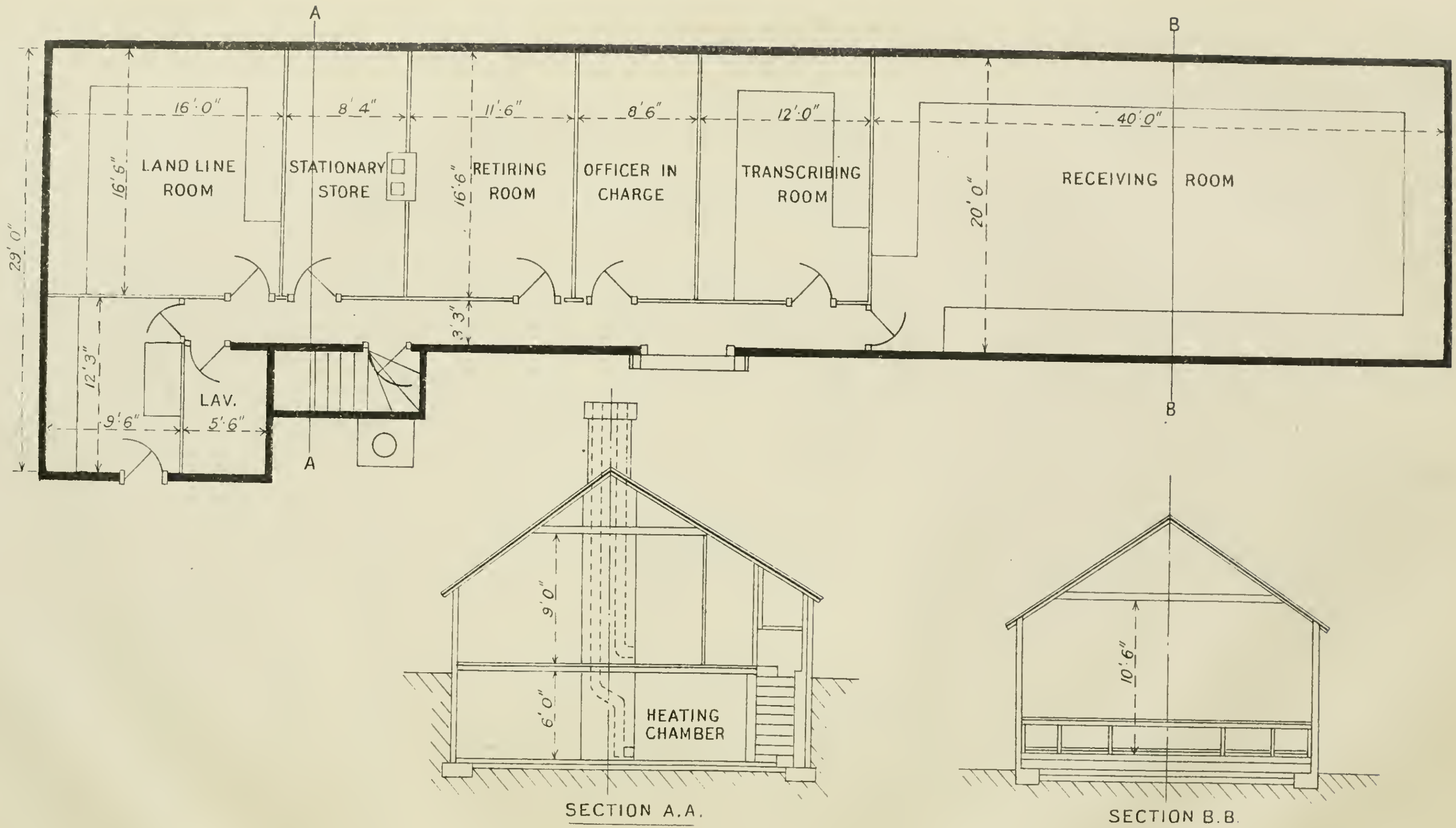

FOR IMPERIAL STATIONS. RECEIVING BUILDING.	*Wireless Section* *Engineer-in-Chief's Office* *G.P.O. London. E.C.*	W.T.C. 22.

Dec. 1921.

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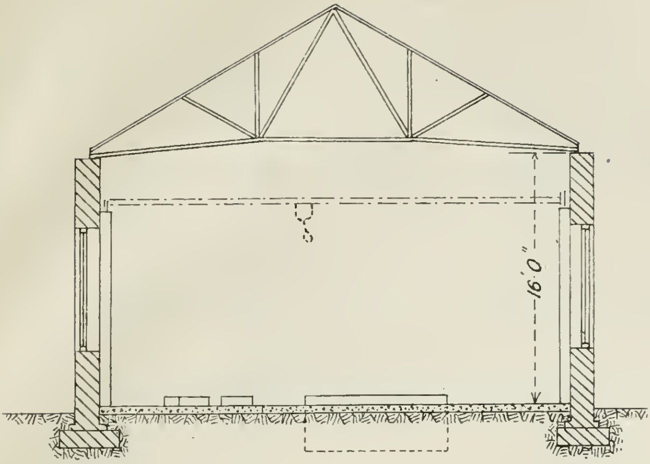
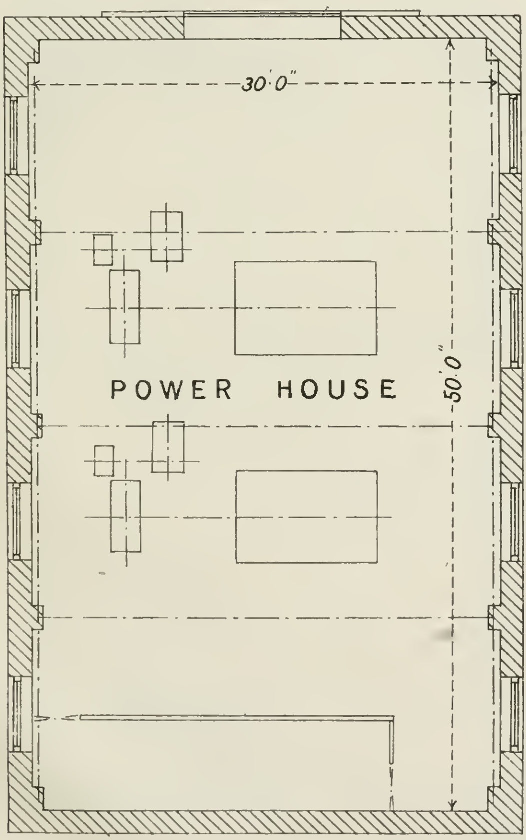


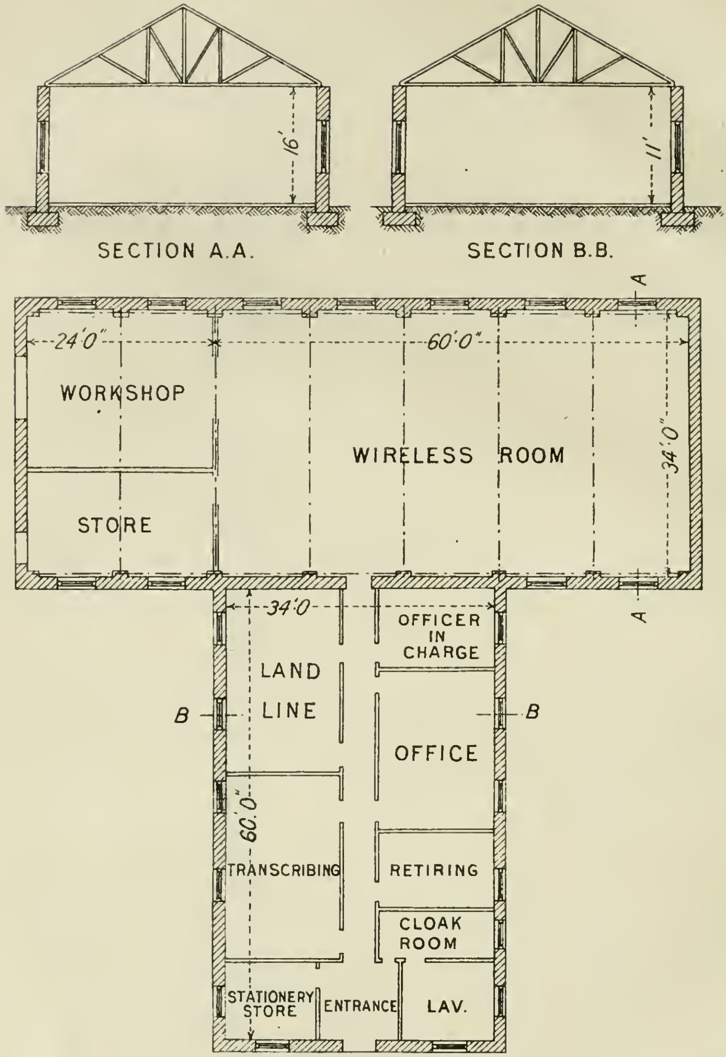


IMPERIAL WIRELESS SCHEME. Proposed Power Building for East Africa

Wireless Section
Engineer-in-Chief's Office
G.P.O. London E.C.
Dec. 1921.

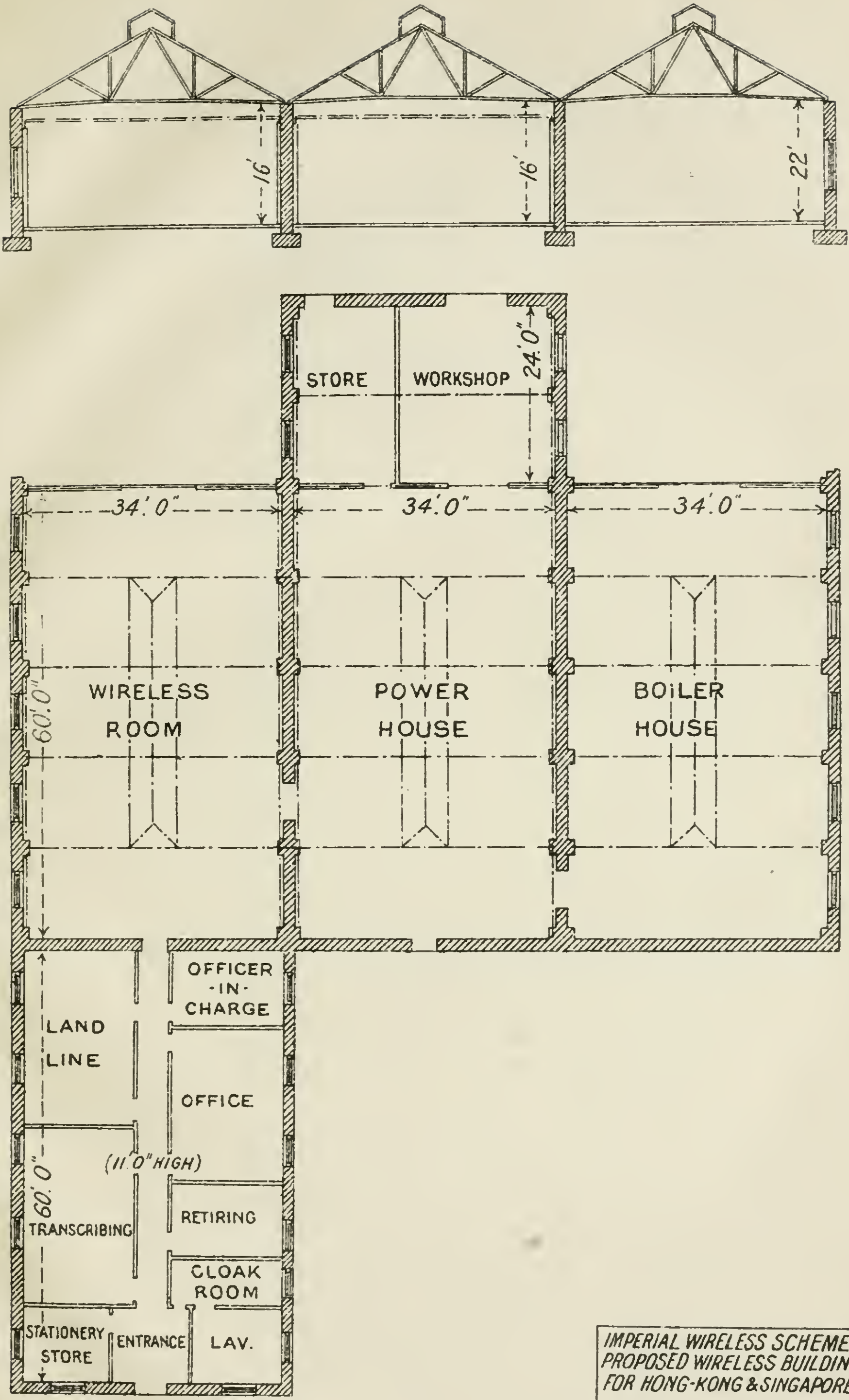
WTC. 23.

Malby & Sons Lith



IMPERIAL WIRELESS SCHEME PROPOSED WIRELESS BUILDING FOR EAST AFRICA	
Wireless Section. Engineer-in-Chief's Office G.P.O. London E.C Dec 1921	WTC.24.

Malby & Sons.Lith



IMPERIAL WIRELESS SCHEME. PROPOSED WIRELESS BUILDING FOR HONG-KONG & SINGAPORE.

Wireless Section Engr.-in-Chief's Dept. G.P.O. London. Jan. 22.

WTC. 25.

435 25794 2.2500.1.22.

Malby & Sons, Lith.

Second Report
of
Wireless Telegraphy Commission

Presented to Parliament by Command of His Majesty

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REPORT.

To the Cabinet,

1. On the 23rd December, 1920, the Wireless Telegraphy Commission was summoned under the following letter of appointment :—

The Cabinet have decided to appoint a Wireless Telegraphy Commission as follows :—

The Right Hon. Viscount Milner, G.C.B., G.C.M.G. (*Chairman*).
W. H. Eccles, Esq., D.Sc., F.R.S. (*Vice-Chairman*).
L. B. Turner, Esq., M.A., M.I.E.E.,
E. H. Shaughnessy, Esq., O.B.E., M.I.E.E.,
Lieutenant-Colonel C. G. Crawley, R.M.A., M.I.E.E. (*Secretary*),

with the following terms of reference :—

(i.) To decide upon the wireless plant most suitable for carrying out the scheme of Imperial wireless communications recommended by the Imperial Wireless Telegraphy Committee, bearing in mind the necessity for the co-ordination of the Chain with existing telegraph services, and to design the necessary stations.
(ii.) To make recommendations regarding the actual sites for the stations proposed by the Imperial Wireless Telegraphy Committee.
(iii.) To advise generally upon the preparation of specifications for machinery and apparatus, the making of contracts and the construction of the stations.

2. A first report was submitted to the Cabinet on the 5th December, 1921, and was printed as Command Paper No. 1572. It contained plans for the erection in England of a wireless station having eight masts 820 feet high on a site 1 mile long by ½ mile wide, and equipped with power plant of 600 kilowatts capacity with a reserve of 300 kilowatts. The report also contained general specifications for stations of about half that size suitable for erection at other points of the Empire as recommended by the Imperial Wireless Telegraphy Committee, 1920.

3. During the year 1922 the Commission was consulted by the Governments of Canada, Australia, New Zealand, South Africa and India, and collected information about the radio-telegraphic features of various Empire sites. Meanwhile, as the proposed stations were the first of their kind and size, practical trials of designs were inaugurated by the Commissioners and carried out in collaboration with the Admiralty and the Post Office engineers. Many large-scale tests were undertaken in the wireless stations already operated by the Post Office. The Commissioners also made a detailed study of newly-constructed large wireless stations in America, France, Italy, Holland and Germany.

4. In February 1923 the Cabinet decided to proceed with the construction of a powerful station in England pending the result of the discussions regarding the proposed stations in the Dominions and India, and Mr. Amery, in his capacity as Chairman of the Imperial Communications Committee, requested the Admiralty, War Office and Air Ministry to send each a representative to the Commission to advise on the needs of the Services as regards the range and situation of the English station and to help in deciding the power and type of the station. The Commission with the Service representatives concluded unanimously that the station should have twelve or sixteen steel masts each 800 feet high, and that the prime movers should have a capacity of 1,000 kilowatts for delivering 500 kilowatts to the antenna. A site near Rugby was agreed to be the best of those available. It was decided that the wavelength should not be greater than 20,000 metres. The use of water-cooled thermionic valves was approved.

5. In accordance with the recommendation of the Imperial Communications Committee, the original Commissioners were to be held solely responsible for all plans and calculations and for all advisory work during the construction of the Rugby station. They therefore determined the general design of the station, and at their instruction all detailed plans and specifications were prepared by the Wireless Section of the Post Office Engineering Department to meet their requirements. This involved the preparation of 559 drawings and 109 specifications. These drawings and specifications were examined and approved by the Commission and the principal tenders obtained were scrutinised before contracts were placed. The buildings were erected by the Office of Works and the whole of the plant was installed by the Wireless Section of the Post Office Engineering Department in close co-operation with the Commission.

6. In April 1924 the Vice-Chairman represented the Commission at the meetings of the Cabinet Committee appointed to expedite the arrangements for wireless communication with the Dominions. The result of these meetings was that an indenture was made on the 28th July, 1924, between the Postmaster-General and Marconi's Wireless Telegraph Company for the construction of wireless beam stations for sending and receiving telegrams between England and Canada, with possible extensions giving similar duplex communication with Australia, South Africa and India. The stations are guaranteed to give daily average communication of 18 hours with Canada, 12 hours with India, 11 hours with South Africa and 7 hours with Australia. In each of these countries the work on corresponding stations is well advanced.

7. The site for the Rugby station is about 900 acres in extent and is situated at Hillmorton, about 4 miles south-east of Rugby. The land is approximately 340 feet above sea level, and the maximum variation in level on the site is 30 feet. The site was chosen to accommodate sixteen masts each 820 feet high placed $\frac{1}{4}$ mile apart. For reasons of economy it was decided to erect

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1000 12/26 [15558]

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only twelve masts in the first instance. Each mast contains about 200 tons of steel and is designed to withstand a high wind pressure with an adequate factor of safety and also to support an aerial which exerts a horizontal pull of 10 tons at the top of the mast.

8. The aerial is constructed in two sections consisting of one large octagonal cage aerial 2 miles long supported on eight masts and another shorter cage aerial $1\frac{1}{4}$ miles long supported on six masts, two of the masts being used in common by both sections of the aerial. In all, about 27 miles of copper cable are used in forming the aerial. The arrangement is such that the two sections can be connected together inside the station buildings to form one large aerial for extreme power, or can be used separately for two transmissions on high power. The earth system consists of an open network containing about 120 miles of copper wire buried a few inches in the ground and occupying a space about 1,600 feet wide under the whole length of the aerial.

9. The station buildings are situated at about the centre of the site and comprise a machinery hall 185 feet long by 47 feet wide by 32 feet high for housing the power plant, and a three-storey building 103 feet long by 42 feet wide by 60 feet high for housing the wireless plant. The power is obtained from a public supply Company, and the power plant installed at the wireless station is capable of converting about 1,800 kilowatts into power suitable for use in the wireless plant. The power is taken by cables from the machinery hall to the wireless building. The high-frequency generator is of the water-cooled valve type. It consists of two exciting units in duplicate and a main power amplifier. The latter consists of five similar power valve panels, each panel containing eighteen valves and capable of giving a high-frequency output of 180 kilowatts at a frequency of 16,000 cycles per second. By using three panels a total output capacity of about 500 kilowatts is available for use on the whole aerial, leaving two panels in reserve. Alternatively, the two sections of the aerial, each working with two power panels, can deal with about 300 kilowatts and 200 kilowatts respectively, leaving one power panel in reserve. Two primary oscillating circuits are provided, one to deal with full power and the full aerial, and the other to deal with smaller power and the smaller section of the aerial. Up to the present the smaller section of the aerial has been reserved for use with an experimental telephony transmitter, and good and reliable two-day conversation across the Atlantic to New York has been obtained repeatedly for many hours of the day.

10. The telegraphy installation has, up to the present date, only been worked on the eight-mast aerial and with about two-thirds power. Even so, the signals have been heard all over the globe. A summary of the reports on the signals received at different distant places is appended. Further experience during bad atmospheric periods will determine to what extent, if any, it will be necessary to extend the aerial by the erection of additional masts.

11. With a view to the most economical and efficient utilisation of the whole of the plant at the station the lay-out was designed

to provide for simultaneous use of two transmitters during the most favourable atmospheric periods. Experiments will shortly be made on the main telegraph transmitter and the transatlantic telephony transmitter to determine whether simultaneous operation is feasible.

12. In addition to the main telegraph transmitter and the transatlantic telephony transmitter, further installations are in contemplation, namely, a short-wave plant and a medium-wave plant, utilising the existing masts for supporting the additional aerials. The development of this multi-way working of the Rugby station can be confidently left in the hands of the Post Office Wireless Engineers.

13. The Commission desires to place on record its cordial thanks for the helpful co-operation unsparingly given by the Admiralty, the War Office, the Air Ministry, the Post Office and the Radio Research Board of the Department of Scientific and Industrial Research. All these Departments have placed at the disposal of the Commission their technical records, their accumulated experience and material facilities for undertaking practical trials of methods and apparatus.

The Commission wishes also to express its deep appreciation of the valuable services rendered by Lieutenant-Colonel Crawley, who has acted as Secretary to the Commission from the beginning of its work.

W. MITCHELL-THOMSON.
W. H. ECCLES.
E. H. SHAUGHNESSY.
L. B. TURNER.

C. G. Crawley, *Secretary*.

2, *Whitehall Gardens*, S.W. 1,
July 7, 1926.

APPENDIX I.

Early Reports received from various Stations during the Testing of the Rugby Station, December 1925.

(These reports are not selected but are given in order of date.)

Date.	Position.	Remarks.
Dec. 10	Off Sicily	Signals good and clear.
11	Halifax	Ten times stronger than Leafield. Copyable, New York, 75 words per minute.
	South Atlantic ...	Signals very clear and very strong. Rugby easily readable above heavy atmospherics and jamming. Leafield has a dead area between Lat. 3° S. and 3° N. Rugby not affected in this area.
	Pretoria	Note very good throughout.
	Cape Town	Note good and steady.
	Suez	Good and clear. Bordeaux signals much stronger than Rugby. Signals two or three times as strong as Leafield.
	Off Aden	Very good and strong. Rugby effectively drowns all interference.
	Mataro	Note clear and steady.
	Bermuda	Note distinct.
	"	Note clear and musical.
12	Off Newfoundland ...	Signals thundering in.
	Newfoundland ...	Signals fine and steady.
	South Atlantic ...	Note good.
	Caribbean Sea ...	Dots indistinct, but improve later.
	Australia (results at various centres)	Note remains constant throughout, signals excellent.
	Off Cape Town ...	Signals and note good.
14	China Station (from Commander-in-Chief)	All ships report note good, clear and steady.
	Halifax	Continuous heavy atmospherics, Rugby easily riding above.
	Newfoundland ...	Fine note, but weaker than on 12th.
	Mid-Atlantic... ...	Note good and steady.
	Sydney	Rugby was only high power European station readable through atmospherics. Good strength and note remained constant throughout.
15	Off Nantucket ...	Atmospherics extremely bad. Rugby signals unaffected, good note.
	Hong Kong	Night telegrams appear to have more solid note.
16	New York	Rugby's signals readable through heavy atmospherics and jamming.
19	South Atlantic ...	All telegrams received, strength 7–9.
	" " ...	Spacing and Morse bad during noon telegrams on Dec. 14.
23	Hong Kong (from Commodore)	All ships report note good, clear and steady.
29	Aden	Note clear and steady.
31	Port Natal	Strength excellent and easily readable above jamming.
	Bandoring (Java) ...	Key action excellent. Frequency very constant.
	Dutch East Indies ...	Rugby splendidly received, far more distinct than any other European station.

APPENDIX II.

Summary of Reports from Ships Equipped with Standard Marine Receiving Apparatus.

(By courtesy of the Marconi International Marine Communication Company.)

Some of these reports are based on the log of a single voyage. All the observations relate to the first few months of this year—a period when atmospheric conditions in the southern hemisphere are at their worst.

In the columns headed "Strength" the figure 1 indicates that signals are just audible, and the figure 6 indicates that the signals are the strongest required in practice.

Locality.	Day Transmissions.	Night Transmissions.	Interference.
ATLANTIC OCEAN—	Strength.	Strength.	
Lat. 60–50 deg. North ...	6 to 9	7 to 9	Considerable jamming by European stations.
50–40 „ ...	6 to 9	7 to 9	
40–30 „ ...	7	6 to 8	
30–20 „ ...	4 to 8	5 to 8	
20–10 „ ...	3 to 8	5 to 8	
10– 0 „ ...	4 to 6	6	
Eastern Atlantic	7 to 9	7 to 9	Considerable jamming by Bordeaux.
North-Western Atlantic ...	6 to 7	6 to 9	Considerable jamming by American stations.
West Indies	3 to 7	5 to 7	Some jamming by American stations.
Gulf of Mexico	3 to 5	5 to 7	
Equatorial Atlantic ...	4 to 6	6	
Lat. 0–10 deg. South ..	5	6	
10–20 „ ...	5 to 6	3 to 7	
20–30 „ ..	5 to 6	4 to 6	
30–40 „ ...	4 to 5	4 to 6	
Central South Atlantic ..	5	5	
Off Brazil	4 to 6	3 to 6	More easily copied day than night owing to atmospherics.
Off Patagonia	1	4	Unreadable during day through interference.
Off South Africa	4 to 5	6 to 7	Atmospherics bad, especially during day.
MEDITERRANEAN ...	4	6 to 8	Some jamming by European stations.
RED SEA	5	7	Ditto.
PERSIAN GULF	5 to 6	7 to 8	Ditto.
INDIAN OCEAN—			
Arabian Sea	5 to 6	7 to 8	
Bay of Bengal	4 to 6	6	
Equator	5	6 to 7	Night transmission better than day owing to disturbance.
Lat. 0–10 deg. South ..	5	6 to 7	
10–20 „ ..	4 to 5	5 to 6	
20–30 „ ...	2 to 5	4 to 8	
Central Area	3 to 5	7 to 8	
South-Western Area ...	4	6 to 7	
Off South Africa	1 to 5	5 to 7	Atmospherics very bad.
PACIFIC OCEAN—			
North-Eastern Area ...	See note	2 to 6	*Note.*—Reception doubtful, due to atmospherics and jamming by American stations.
Off Japan	3	4	Some jamming by Japanese stations.
China Seas	3	3	Some jamming.
East Indies	No observations	6	
Off Mexico	„	1 to 3	
Gulf of Panama	0 to 4	2 to 4	Unreadable through atmospherics.
Off South America ...	3 to 4	3 to 4	Considerable jamming by American and Argentine stations.
Central South Pacific ...	4 to 5	4 to 5	
Off Cape Horn	No observations	5	
AUSTRALASIA—			
Off Northern Australia ...	No observations	6	
Off Western Australia ...	4	4 to 6	
Australian Bight	3 to 4	5 to 6	
North of Tasmania ...	4	5	
Off Sydney...	4	5	
Off Brisbane	4	5	
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